THE CRETACEOUS RIM OF THE BLACK HILLS.[1]

As is well known, the Black Hills District was surveyed by the party in charge of Professor W. P. Jenney in 1875, the geological report being written by Professor Henry Newton, whose death occurred two years later. The report, edited by Mr. G. K. Gilbert, was published in 1880 by the U. S. Geographical and Geological Survey of the Rocky Mountain Region in charge of Major J. W. Powell. The peculiar and interesting geological features of this remarkable outlier of the Rocky Mountain range need not be set forth here further than to say, that on all sides after leaving the central nucleus of eruptive rocks sedimentary deposits occur with diminishing dip in an ascending geological order. First, there is a narrow ring of Potsdam sandstone; then a wide belt of Carboniferous limestone; next an encircling trough, aptly compared by Professor Newton to a moat, of red sandy gypsiferous clays, in which is included a purple limestone terrace, all of which is supposed to be Triassic and to be the equivalent of the "Red Beds" of more southern regions; skirting this is a very narrow border of highly fossiliferous light colored Jurassic clays or marls; then come the foot-hills, which consist of Cretaceous sandstones and shales referred by Professor Newton to the Dakota, No. 1, of Meek and Hayden's section; these slope back to the dark shales of the Fort Benton group, which are succeeded by higher Cretaceous beds that extend to the plains and pass under the Bad Lands of the White River formation.

The belt of Cretaceous, which lies outside the Red Beds and Jurassic and forms the foot-hills, constitutes an elevated rim with an escarpment at its inner margin rising abruptly above the Triassic trough, the Jurassic exposures being often confined to the lower part of the escarpment. This cannot be better rep-

[1] Published with the permission of the Director of the U. S. Geological Survey.

resented than in the following figure copied from Professor Newton's report:[1]

At that date the opinion widely prevailed that there was no Lower Cretaceous in North America. The Shasta, Kootanie, and Comanche groups were unknown, the Potomac of Virginia was supposed to be "Upper Oolite," and the Iron Ore Clays of Maryland and Plastic Clays of New Jersey were classed as Wealden and referred to the Jurassic. Meek and Hayden had been unable to find any Cretaceous deposits lower than No. 1 of

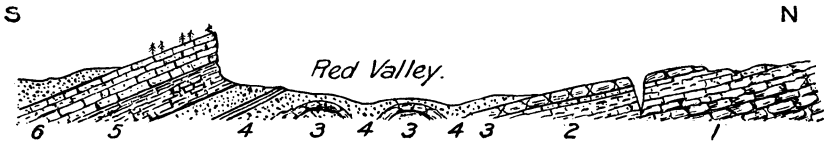

FIG. 1.—Ideal section across Red Valley on Amphibious Creek.

1. Carboniferous.
2. Red sandstones and clay (Red Beds).
3. Purple limestone (Red Beds).
4. Red clay with gypsum (Red Beds).
5. Jura.
6. Cretaceous sandstone capping the foot-hills.

their famous section, and this was believed to be the oldest Cretaceous deposited on this continent, which was supposed in some way to have been out of water during the entire period that separated this from the Jurassic.

My attention was first attracted to the Black Hills by a letter received at the Smithsonian Institution in February, 1893, from a resident of Hot Springs, South Dakota, inclosing photographs of certain petrifactions found in that vicinity which he said had been called "Cycads." The letter and photographs were referred to me on the presumption that these objects were of vegetable origin. I at once perceived that they were fossil cycadean trunks closely resembling those collected by Tyson in 1860 in the Iron Ore Clays of Maryland and named by Professor Fontaine *Tysonia Marylandica*, and, therefore, also similar to the forms found by Mantell and others in the early part of the cen-

[1] Geol. Black Hills of Dakota, p. 141, fig. 20.

tury in the Purbeck beds on the Isle of Portland and at other points in the South of England. Being greatly interested in the discovery, I recommended that the proprietor be requested to send on a specimen for examination. The request was complied with, and the specimen proved to be all that I had expected. I therefore made the further recommendation that negotiations be entered into with a view to the purchase of the collection of six specimens which were offered for sale. This was also successful and the collection arrived in May.[1] One of the chief features of these specimens is the great size of some of them, the largest measuring 30 inches in height, 2 feet in its longest diameter, and weighing 900 pounds, thus far exceeding anything of the kind hitherto known from any other part of the world.

Fossil remains of cycadean trunks range from the Upper Trias to the Lower Cretaceous. A number have been found in the clay shales of Italy which have been referred to the Cenomanian, but will probably be found to be lower. Hot Springs is located on the Red Beds in the valley of the Minnekahta creek, or Fall River, and it would have been natural to suppose that the cycad trunks had come either from these or from the Jurassic which borders it, had it not been stated that they were found "on a high hill." My interest was of course strongly aroused to know the stratigraphical position of the beds in which they occurred, and therefore early in September I made an expedition to the region for the purpose of determining it if possible. I had previously corresponded with Mr. F. H. Cole, of Hot Springs, from whom the specimens had been purchased. I had also written to Professor Jenney, who was then at Deadwood, and who kindly consented to join me on my arrival and aid me in the investigation. After considerable search and some difficulty the locality was at length found. It is some four miles southwest of Minnekahta Station, about two miles west of Minnekahta Creek, which here has a northward course, on foothills one and a half miles east of the divide between that and Red Valley. A deep cañon lies to the south, which has an east

[1] See Science, Vol. XXI., No. 543, June 30, 1893, p. 355.

course and opens into the Minnekahta Valley. The locality is on the southeast slope, just below the top of the flat-topped spur-ridge and near the abrupt descent into the cañon. From this point northwest to near the crest of the divide the slope is moderate and nearly uniform.

The accompanying sketch-map (Fig. 2) showing the drainage of the region north of the south fork of the Cheyenne river, the Minnekahta Valley, and part of the Red Valley, will enable the reader to understand the general character of the country covered by this reconnaissance.

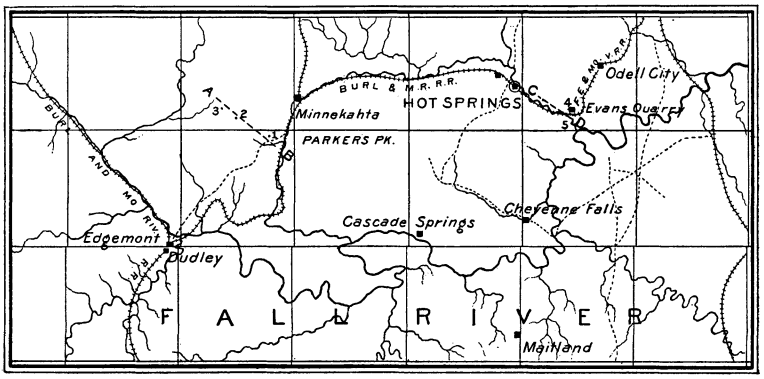

FIG. 2.—Sketch-map of a portion of Fall River County, South Dakota.

A B. Section No. I.
1. Cycad bed.
2. Fossil forest.
3. Plant bed.

C D. Section No. II.
4. Upper leaf bed.
5. Lower leaf bed.

At the foot of this crest on the same (southeast) side, and about one and a half miles northwest of the cycad locality, occurs an extensive fossil forest. The wood is all completely silicified, and consists of prostrate trunks of various sizes and lengths and an abundance of smaller fragments, many of which are scattered about on the sloping plain a long distance below the actual horizon at which they were petrified. At that horizon many still remained apparently undisturbed, and in one place a trunk eight inches in diameter was seen projecting several feet from beneath the massive sandstone ledge. To the south of this point is a

saddle, beyond which the crest of the divide is lower, and here the forest is seen to the best advantage. The most prominent object is an immense trunk, thirty inches in diameter and twenty feet long, lying where it fell at no very remote date, having broken from its roots at the surface of the ground, leaving portions of the stump still exposed. The entire root could probably be exhumed. About the present trunk the lines of splinters and smaller fragments clearly indicate the character of its branches and show that these branches remained attached at the time it fell. A considerable amount of silicified wood occurs also at the same locality as the cycads, obviously preserved by the same influences that preserved the latter. The slope from the fossil forest to the cycad bed is about the same as the dip of the strata. It is therefore probable that both occur approximately at the same horizon. The whole of this region, including the entire crest of the divide and extending to the bottom of the cañon below the cycad bed and far to the southeast, consists of the series of sandstones that have been treated in the Black Hills report as the "Dakota Group."

The great improbability that the cycads could have lived in the Dakota period, or Upper Cretaceous, led us to undertake an investigation of these rocks with a view to the possible discovery of additional evidence of their age. No other fossil remains than the wood and cycad trunks could be found in the immediate vicinity or anywhere on the outer slope of the Cretaceous rim. The crest above the fossil forest consists of harder sandstones, chiefly massive, which may be traced far around the Hills, and which form the upper part of the abrupt escarpment above the soft Jurassic and Red Beds. Passing over this to the northwest we descended into the first lateral cañon entering Red Valley from the northeast. The Jurassic is passed through and the Red Beds fairly entered in the descent. Fifty to seventy-five feet above the Jurassic contact and 175 to 200 feet below the summit of the crest, argillaceous shales with some carbonaceous matter occur interstratified with the sandstones, and at this level, partly in the shales and partly in the rocks, a few fos-

sil plants were found and a small collection made. They bore no resemblance whatever to the flora of the Dakota Group, but consisted chiefly of ferns with a few coniferous twigs and possibly cycadean remains. In short the flora, so far as I could judge, was rather that of the Lower Cretaceous.

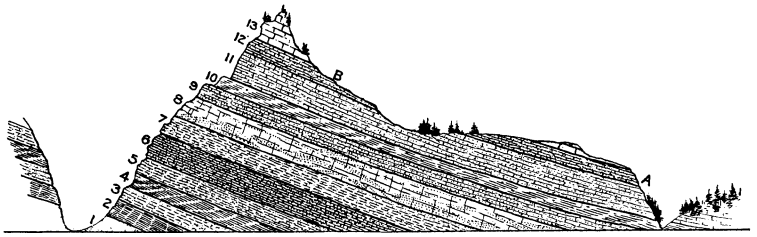

FIG. 3.—Section across the divide between Red Valley and Minnekahta Creek.

1. Red Beds.
2–7. Jurassic.
9. Plant Bed.
12. A, Cycad Bed. B, Fossil Forest.
13. Equivalent of Quarry Sandstone in Section No. II.

The entire section, from the Red Beds at the bottom of the cañon to the summit of the crest forming the divide, was carefully measured, the position of the fossil forest bed, the cycad bed, and the plant bed, fixed as nearly as the circumstances would permit, and all the variations in the nature of the strata indicated. The section, as determined on the spot, is as follows:

SECTION NO. I.

Dakota of Newton. 275 Feet.

13.	Massive pinkish sandstone approaching a quartzite locally	75 feet
12.	Grayish white sandstone with silicified wood and cycads	30 feet
11.	Pinkish and yellowish soft sandstone	75 feet
10.	Clays with indications of coal	20 feet
9.	Soft pink and gray sandstone with ferns and other plants	25 feet
8.	Reddish, pinkish, and yellowish brown massive cross-bedded sandstone	50 feet

Jurassic. 220 Feet.

7.	Olive gray clay and sandstone shales	50 feet
6.	Light red soft sandstone	60 feet
5.	Olive gray clays and gray sandstone shales	40 feet
4.	Olive drab clay	20 feet
3.	Yellow sandstone shales	20 feet
2.	Olive drab clay	30 feet

Red Beds (Trias).

1.	Red marls, conformably exposed at bottom of cañon	20 feet

This section may be represented diagrammatically in Fig. 3.

The Minnekahta Creek, or this southern fork of it, after flowing north through the Cretaceous, enters the Red Beds a little south of the Minnekahta Station, after which it bends to the eastward and follows the strike to Hot Springs. Below this point it takes a southeasterly course, and soon reënters the Cretaceous, cutting entirely through the sandstone and entering the dark Fort Benton Clays a short distance below the cataract at the electric light plant nearly five miles from Hot Springs at Evans Siding. Evans Quarry is just above this point on the left bank. At the last named place Professor Jenney had formerly obtained dicotyledonous leaves, and it was his impression that these might have come from near the horizon of the cycad bed. This region presents an admirable opportunity for measuring a section of the Cretaceous, which it was very desirable to do for comparison with the one last given.

The distance at the bottom of the valley from the Jurassic contact to the Fort Benton is about three miles, and the dip, as the section shows, is over 100 feet to the mile. The quarry is about one-half mile from the point where the sandstones pass under the Fort Benton shales. It has a thickness in workable stone of about 60 feet, and is immediately capped by 40 or 50 feet of softer material. It dips very rapidly to the southeast so as to come down to the stream at the electric light plant, and constitute the rock over which the cataract flows and through which the water has here worn deep longitudinal grooves. Immediately over these rocks and resting upon them there is a bed some six or eight feet in thickness of dark clay and argillaceous shales with carbonaceous matter and some impure coal. In this bed was found a great abundance of more or less comminuted vegetable matter, with short fragments of culms or reed-like plants not determinable. There also occurred in certain of the shales a few tolerably well preserved dicotyledonous leaves, some of which are determinable. They were at least sufficient to indicate with practical certainty that this stratum belongs to the Dakota Group of Meek and Hayden (No. 1). A small collection was made at this point, viz., at the cataract

over the hard sandstones on the right bank of the stream above the electric light plant (5, Fig. 2).

This bed was easily followed to the quarry, where it constitutes the overlying mass which it is necessary to remove in order to uncover the workable sandstone below. At this point the bed also contains layers of soft white sandstone more or less massive. Large blocks of this had been thrown down and lay strewn at the foot of the quarry. On the surfaces of these and more or less scattered through their mass were impressions of dicotyledonous leaves of Dakota types. The shales were also found in places above the quarry, and some of these yielded very good specimens (4, Fig. 2).

The massive sandstone of the quarry is entirely barren so far as could be ascertained, and no fossils were found at any point lower than the bed that overlies it. For a long distance on both sides of the cañon it forms the crest of the ridge, presenting a more or less abrupt escarpment of from 25 to 75 feet. Below it, higher up the stream, beds of softer sandstone, argillaceous shales, and carbonaceous layers with impure coal seams, all highly charged with gypsum, come down to the bed of the stream, and are finally seen resting upon the Jurassic clays, which in turn overlie the Red Beds. Some distance below Hot Springs the Cretaceous can be seen at the summit of the cliffs, with the whole thickness of the Jurassic below them and the Red Beds at the base. At and about Hot Springs there are some heavy beds of conglomerate about which little seems to be known.

The following is the Cretaceous section as measured:

SECTION NO. II.

Fort Benton.

11. Grayish black clays with layers of ferruginous concretions, extending to the south Fork of the Cheyenne River—contact conformable.

Dakota of Newton. 339 Feet.

10. Pink sandstone, mostly thin-bedded, with ripple-marks and fucoid-like impressions ..... 30 feet
9. Soft black shales with traces of carbonized plant remains and some fragments of fossil wood ..... 15 feet
8. Pink and gray sandstone ..... 30 feet

7. Clay shales and sandstones, the latter sometimes white, all plant bearing, much comminuted vegetable matter, matted beds of swamp plants, and well-preserved dicotyledonous leaves of Dakota types, determinable... 10 feet
6. Black clay full of carbonaceous matter, with locally six inches of impure coal ..... 4 feet
5. Quarry sandstone, massive, light pink, soft, weathering iron-brown..... 60 feet
4. Soft yellowish and reddish sandstones .....100 feet
3. Drab-colored clays with carbonized vegetable matter and gypsum crystals, interbedded with yellow sandstones ..... 30 feet
2. Soft yellow and reddish sandstones with some clay layers ..... 60 feet

Jurassic.

1. Olive gray, drab or bluish clays with reddish and yellowish sandstones, to base.....

This section may be represented diagrammatically as follows:

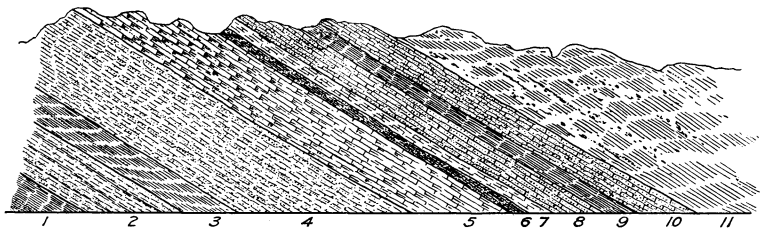

FIG. 4.—Section through Minnekahta Cañon.

1. Jurassic.
3. Equivalent of plant bed in Section No. I.
4. (Upper portion). Equivalent of cycad bed in Section No. I.
5. Quarry sandstone.
7. Dakota leaf bed.
11. Fort Benton.

It will be seen by a comparison of these sections that they are in substantial agreement, although no effort was made to make them so. The crest of the divide in section I represents the Quarry sandstone of section II, which was probably considerably thicker at this point, fifteen feet more being found, exclusive of erosion, but these rocks were often much harder in section I, and no quartzitic rocks were seen in the quarry. On account of the debris thrown down from the quarry and other obstructions, it was not possible to examine the next member below with as much care as was desirable in view of the fact that it seems to be the equivalent of the cycad and fossil forest horizon of section

I; *i. e.*, No. 12 of section I corresponds to the upper 30 feet of No. 4, section II.

At Minnekahta Station, in an ornamental heap of various minerals and rocks from the Black Hills, there were a number of fragments of cycads and fossil wood. We were told that these came from a ridge two miles to the southeast of the station that rises above the Red Beds and shows at its base low buttes and a considerable thickness of Jurassic. This was not visited, but it was evident that the summit of this ridge was formed by the hard sandstone No. 1 of section I (No. 5 of section II), which is continuous to Evans Quarry. The position of the cycad and fossil forest bed here is doubtless the same as on the opposite side of the valley where it was studied.

The occurrence of two other specimens of cycadean trunks, though apparently belonging to a different species, in the same general horizon on the east side of the Black Hills, and of silicified wood in the northern districts, seems to indicate that the same relations obtain on all sides, and this will probably be found to be the case.

The fossil plants of the lower horizon were sent to Professor Fontaine for determination, and the following extracts from his report upon them will show that my interpretation of their significance at the time of their discovery was for all practical purposes correct.

"The best preserved fragments are scattered leaflets, and the summits of the ultimate pinnæ of ferns, which are the parts of those plants which have great value in fixing species. The following are the plants:

"1. The summits of ultimate pinnæ of a fern, which is decidedly like *Asplenium Dicksonianum* Heer, from the Kome beds of Greenland. It has also something of the character of the widely diffused Potomac plant, *Thyrsopteris rarinervis*, but is, I think, nearer Heer's plant.

"2. Some ends of the ultimate pinnæ of a small fern with the facies of a Gleichenia. This is nearest to Heer's *Gleichenia Zippei*, from the same Kome beds, but the pinnules are rather more acute

than most of those of that plant, and indicate that those on this plant, lower down, are somewhat larger than those of *G. Zippei.* The form is also something like *Aspidium heterophyllum*, of the Potomac, but seems to be smaller and more delicate. It may however be the same.

"3. The most common fossils are fragments of detached leaflets and one entire leaflet, of a plant which is strikingly like a Neuropteris of the coal measures (*N. flexuosa*). I am pretty sure, however, that it is a Glossozamites, a form of cycad that has leaflets which, in form and nervation, closely resemble Neuropteris. This, if a Glossozamites, has leaflets proportionately broader and shorter than any known to me, and it is probably new.

"4. There are a number of imprints left by organisms which in shape, dimensions, etc., would agree with fragments of the leaves of Pinus, or of Leptostrobus, but as nothing of the nervation is shown, it is not possible to say which they are. Some of the imprints are too deep and open, apparently, to have been formed by leaves. They seem to have been straight, slender stems.

"It will be seen from this account that the plants, so far as one can judge from such imperfect material, indicate a lower Cretaceous and Neocomian age, with rather more resemblance to the Kome than Potomac phase or grouping, but it is by no means certain that the Potomac grouping is not nearest to that here shown."

Thin sections of some of the silicified wood have been made and microscopically studied by Professor F. H. Knowlton. He reports the results as follows:

"The structure of this wood is very finely preserved, and a glance suffices to show that it possesses the Araucarian type and represents, with little question, an undescribed species of the genus Araucarioxylon. The wood-cells are provided with two rows of alternating hexagonal pores on the radial walls, which nearly, or in some cases, quite cover the walls. The medullary rays are composed of a single layer of thin, short cells, each of which is covered on the radial side with numerous fine dots or punctations. The rays are from one to bout twenty cells high, the average number being perhaps eight or ten. A

large number are composed of only one or two cells. The annual rings are rather indistinct, yet can be made out.

"As far as I now know, only two species of Araucarioxylon have been described from the United States, *A. Arizonicum* Kn., from the Triassic or Lower Jurassic of New Mexico and Arizona, and *A. Virginianum* Kn., supposed at first to belong to the Potomac formation, but now known to be from the Trias of Virginia. These species differ markedly from the one under discussion. With the *A. Arizonicum* it has almost no points in common, while it differs from the *A. Virginianum* in important particulars."

The only sections of the fossil wood that have yet been made were cut from a specimen taken from the cycad bed proper and not from the principal fossil forest, but it often happens that only one species can be found in such a forest. It is therefore probable that the same structure would be shown by the other specimens. I confess to a little surprise at finding that this structure represents the Araucarian rather than the Sequoian type of conifers, since, in the east at least, these two types characterize the Trias and Potomac respectively, no Araucarian specimens having been found in the Potomac and no Sequoian specimens in the Trias. And generally the Araucarian type is more ancient. This evidence therefore points to a lower instead of a higher horizon.

I have made a somewhat careful study of the specimens from the plant bed above Evans Quarry, and have asked Professor Knowlton to assist me, his experience in recently editing Lesquereux's Flora of the Dakota Group having familiarized him with the forms of that age. The result of our joint investigation may be summed up as follows:

The specimens are few and fragmentary, and the only species that can be even approximately determined are:

Asplenium Dicksonianum Heer.
Quercus Wardiana Lx.?
Lindera venusta Lx.
Aralia Towneri Lx.?
Virbunites Evansanus n. sp.

The first of these was described by Heer from the Kome beds of Greenland (Gault or Urgonian), but it also occurs in the Atane beds, which are correlated with the Cenomanian and have been supposed to be nearly equivalent to the Dakota Group. It has been found in the Kootanie deposits of British America, in a supposed Neocomian deposit at Cape Lisbourne, Alaska, and in the Amboy Clays at Woodbridge, New Jersey. It is also one of the few ferns that have been found in the Dakota Group, where, however, it is rare. Its evidence, therefore, considered by itself, would be to put even this uppermost deposit in the Lower Cretaceous, but this is overcome by that of the remaining forms. The specimens are the best in the collection, good and characteristic, leaving no doubt on the score of identity.

Quercus Wardiana Lx., is an exclusively Dakota form, but the specimens are too imperfect to make the determination sure.

Lindera venusta Lx., is a characteristic Dakota species, and one of the specimens leaves no doubt as to identity.

Aralia Towneri Lx., is also confined to the Dakota Group, but the specimens, though tolerably good, do not exactly agree, the lobes being too short. They most resemble the specimen figured by Lesquereux in his Flora of the Dakota Group, pl. xxxi, fig. 3, which he doubtfully refers to *Sterculia Snowii* Lx., but which does not at all resemble the type specimens of that species, and probably belongs to *Aralia Towneri*.

The leaf which I name *Viburnites Evansanus*[1] is one of the best preserved in the collection, but it differs specifically from all the forms known to me. It is clearly of the type of *Viburnites crassus* Lx., and *V. Masoni* Lx., of the Dakota Group (Fl. Dak. Gr., pp. 124, 125; pl. xlv), but is longer in proportion to its width with a larger number of secondary nerves, which are irregularly disposed, the angle differing on the two sides of the midrib, as do also their number and proximity. The branching is strictly dichotomous and the finer nervation is distinct. The margin is only preserved near the summit, but here it is that of *V. crassus*.

[1] For Mr. Fred. Evans, proprietor of Evans Quarry, founder and leading citizen of Hot Springs, who greatly aided and facilitated the expedition.

It thus appears that the flora of the beds above Evans Quarry is distinctly that of the Dakota Group, while all the plants found below that horizon as distinctly indicate a Lower Cretaceous age. The force of this evidence is to my mind irresistible, and it is safe to predict that if any other paleontological evidence is ever found it will confirm this conclusion. The question still remains as to where the dividing line is to be drawn. Between the cycad and fossil wood horizon and that of the Dakota leaves there are some hundred feet of sandstones and shales. Sixty to seventy-five feet of this consists of the massive or heavy-bedded building stone, which in places becomes flinty and very hard. As the thin shaly layer which separates this from the leaf bed may be safely put with the latter into the Dakota proper, and there seems no reason for separating the similarly constituted layer that intervenes between the cycad horizon and the base of the sandstone from the one upon which it rests, the question is narrowed down to that of the position of the quarry sandstone. That question I will leave to the stratigraphical geologists.

As to where in the Lower Cretaceous series the basal portion of the Cretaceous rim of the Black Hills should be located, it can only be said that the cycadean trunks elsewhere found in North America have all come from well down in that series or else from the Upper Trias. Leaving the latter cases out of the account we have the Maryland specimens and the one from Kansas. It was long supposed that the Maryland specimens were derived from the Iron Ore Clays, which were referred by McGee and Fontaine to an "Upper Clay Member." This is now known not to be the case, and it has been demonstrated that the cycads occur in the basal sands at the same horizon as the Sequoian trunks, and probably the same as the Rappahannock freestone, which has yielded more fossil plants than any other horizon. Whether this is the same horizon as that of the James river, where cycads and conifers prevail and no dicotyledonous leaves have been found, or a somewhat higher one, need not now be discussed, as the whole subject will soon be thoroughly presented along with the evidence. Certain it is that the Potomac

cycads belong to the lower part of that formation. The Kansas specimen is confidently referred by Professor Cragin to the Trinity Group of the Comanche series of Hill, which forms the lowest division of that series. Professor Hill is disposed to accept this conclusion, and Professor Prosser of Washburn College, Topeka, sees no reason to doubt its accuracy.

The other plants, as has been seen, occur about one hundred feet below the cycad bed. Professor Fontaine's report above quoted places their significance in its true light and leaves little to add. The occurrence of *Asplenium Dicksonianum* shows simply that this common form persisted in the same area through a long period. But this it was already known to do. Should it, however, prove to be the *Thyrsopteris rarinervis* Font., it would be a characteristic lower Potomac species.

The forms that Professor Fontaine refers to Glossozamites argue entirely for a Lower Cretaceous or even earlier age. Eight species of that genus are known, ranging from the Upper Trias to the Urgonian. Some are from the Lias, but most of them are found in the Wealden and Neocomian. They had a wide geographical range, occurring in Greenland (Kome beds), India (Damuda series), and in various parts of Europe. One species, *G. distans*, is from the lower Potomac of Fredericksburg, Virginia.

Gleichenia Zippei (Corda) Heer was first described by Corda, who referred it to Pecopteris, from the Gosau formation of Bohemia, supposed to be above the Cenomanian. It has since been found in the true Cenomanian of Bohemia and in the Quadersandstein of Germany. Heer found it in all the Cretaceous beds of Greenland (Kome, Atane, Patoot), also in the Cretaceous of Spitzbergen. Newberry detected it in the Amboy Clays. It varies considerably, and the name may include more than one species. Fontaine compares the Black Hills specimens only with Heer's Kome forms, and is not certain that they may not rather represent his own *Aspidium heterophyllum* from the Lower Potomac of Fredericksburg. The evidence afforded by this species, therefore, is not strong, but it certainly does not occur in the Dakota Group elsewhere so far as known.

Leaves of Pinus and Leptostrobus occur quite frequently in the Potomac formation in Virginia, Alabama and New Jersey, but have never been found in the Dakota Group. So far, therefore, as these forms from the Black Hills go they favor the view that the bed in which they occur is Lower Cretaceous.

The chief argument from the plants is that they were all of humble types, no dicotyledonous leaves occurring among them. The force of this argument may be appreciated when it is remembered that the flora of the Dakota Group, one of the richest fossil floras of the world, consists, as now published, of 460 species, of which 429 are Dicotyledons. There are only 6 ferns, 12 cycads, 15 conifers and 8 monocotyledons. The cycads are only known by fragments of fronds or pinnæ, and a few doubtful fruits. The chances are hundreds to one that any plant bed of that age will contain dicotyledonous leaves in profusion, and the lower forms very sparingly, if at all. This was found to be the case at the real Dakota plant bed above Evans Quarry. Only one fern was obtained, while leaves were abundant though difficult to secure entire with the insufficient appliances with which we were provided.

A closing word on the bearing of these facts upon the Lower Cretaceous of North America may be permitted. It would seem probable that a considerable portion of the deposits underlying the marine Cretaceous of the Rocky Mountain region which have heretofore been referred to the Dakota Group on purely stratigraphical evidence may really be much older. When in 1883 I descended the Missouri River from the mouth of Sun River to Bismarck, most of the way in a "mackinaw," and in company with Dr. C. A. White, that able geologist was of the opinion that the rocks at the Great Falls of the Missouri belonged to the Dakota Group. They were seen distinctly passing under the Fort Benton shales below, and there were no more indications of a division line at any point in the series than Professor Newton found in the same section of the Black Hills. As no Cretaceous older than the Dakota Group was at that time supposed to exist in that region, it was natural to refer all below the Fort Benton to

that group. But when a rich plant bed was at length discovered at Great Falls it was found to belong to the Kootanie group of Dawson, as developed in regions nearly north of this point. Here then is another series in which the dividing line between the Upper and Lower Cretaceous has to be found.

It would, perhaps, be rash to predict that like conditions will be found to prevail at most points along the slopes of the Rocky Mountains, but the facts are sufficient to constitute a good working hypothesis, and a systematic search at various points in the rocks that overlie the Red Beds and the Jurassic wherever these occur may result in further valuable discoveries. One additional fact that points in this direction may be noted. There was picked up on the surface within the Laramie terrane at Golden, Colorado, a segment of a small cycadean trunk which Lesquereux called *Zamiostrobus mirabilis*, but which has been sent to Count Solms-Laubach, Professor of Botany at the University of Strasburg, and the leading authority on the subject, and pronounced by him to be a trunk and not a cone (as, indeed I had myself previously stated),[1] referable to the genus Cycadeoidea. This region, as most geologists know, lies at the foot of the Front Range, and marine Cretaceous passes under the Laramie at Golden. The several members of the Cretaceous, in descending order, would naturally be found in passing up the adjacent slope, and if a horizon yielding cycad trunks occurs here it would be very natural that some of these cylindrical trunks should roll down the steep escarpment and be arrested on the plain below where this specimen was found. This explanation is far more probable than that this form could have grown in Laramie time, though no one can say that this is impossible, especially as the specimen is a diminutive one and may represent the degenerate descendants of the robust forms of the Lower Cretaceous.

Whatever future consequences may grow out of the discoveries recorded in this paper they at least, in and of themselves, constitute a fresh contribution to our rapidly growing knowledge of one of the hitherto least known periods of North American geology, to wit, the Lower Cretaceous.

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[1] Science, Vol. III., p. 533 (1884).